

- Washington. The collections were made in 1929, 1949 and 1950.
2. A total of 220 species, 67 genera and 23 families was determined.
 3. The genera with the largest representation are as follows: *Cosmarium*, 26; *Staurastrum*, 19; *Closterium*, 16; *Euastrum*, 12; *Scenedesmus*, 12.
 4. The families represented by the largest number of species are the following: Desmidiaceae, 110; Chroococcaceae, 17; Oscillatoriaceae, 12; Nostocaceae, 12; Scenedesmaceae, 12.
 5. Terrell Lake had the most varied algal flora with 70 species, Judson Lake was second with 58 species, and Willey's Lake was third with 40 species.
 6. The paucity of literature concerning the fresh water algae of this area has prompted the writing of this paper. Since little or no prior investigation had been conducted on these particular lakes, the species herein reported represent for the most part new records for this locality.

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A CYTOTAXONOMIC STUDY OF THE GENUS GERANIUM IN THE WASATCH REGION OF IDAHO AND UTAH

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Within the limits of the small but natural geographical area known as the Wasatch region, the genus *Geranium* has been given much needed intensive field study. The Wasatch region forms the western front of the Rocky Mountain province and extends 200 miles south from the great bend in the Bear River at Soda Springs, Idaho, to the pass south of Mount Nebo and east of Nephi, Utah (Fenneman, 1931) and includes twelve counties within these two states. The collections and the field studies of the species of *Geranium* found in this area, together

with greenhouse studies, are the bases for the taxonomic treatment given herein. In addition, cytological analysis of the genus has also been made, with emphasis placed on chromosome numbers in order to show evidence for and possible origin of polyploidy.

LITERATURE

The first comprehensive monographic study of the North American species of *Geranium* was published by Hanks and Small (1907). This included sixty-four annual and perennial species, thirty-one of which were native to Mexico. In 1912, R. Knuth prepared a world-wide monograph in which the treatment of North American species follows in part the pattern of Hanks' and Small's earlier work. The annual species were treated very briefly and incompletely by Fernald (1935). Jones and Jones (1943) presented a taxonomic revision of the perennial species of the United States and Canada in which eighteen species were recognized.

The first cytological work was done in Europe by Tjebbes (1928) when he published the chromosome numbers of two species (*G. pratense* L., $n=12$ and *G. sylvaticum* L., $n=12$). Gauger (1937) submitted a list of chromosome numbers of twenty-three European species of the genus, six of which have become established in North America as weedy annuals.

MATERIAL AND METHODS

Observations of chromosome numbers and behavior were made from pollen mother cells and root tips. Root tips were taken from germinating or potted plants grown from seed or transplanted from the field. In one case the root tips were grown from seeds of a herbarium specimen which was nineteen years old, indicating extraordinary seed viability. Both anthers and root tips were killed and fixed in a fresh solution of absolute alcohol and glacial acetic acid (3:1) for twenty-four hours and then smeared using iron-acetocarmine technique. Most of the temporary mounts were made permanent. All source material is on deposit at the Intermountain Herbarium, Utah State Agricultural College, Logan, Utah, with the exception of one herbarium sheet which is at the Idaho State College Herbarium, Pocatello, Idaho.

Field work was carried on for two summers, principally in the many canyons which cross the Wasatch Mountains from east to west. The specimens collected are in the Intermountain Herbarium, Utah State Agricultural College, Logan, Utah. Additional herbarium specimens from the following sources were studied: Gray Herbarium, New York Botanical Garden, Herbarium of Idaho State College, Herbarium of University of Utah, and Intermountain Herbarium, Utah State Agricultural College.

All of the species of *Geranium* discussed in this study were grown in the greenhouse during 1949 and part of 1950. The main purpose of these greenhouse studies was to check the consistency of various morphological characters which have taxonomic significance. The information thus gained has been included as supporting evidence in the following section.

RESULTS

A detailed study of meiosis and of chromosome morphology was difficult because of the extremely small anthers and chromosomes. Meiotic divisions were not observed in the annual species. In the perennial species, however, several meiotic divisions were seen. Diakinesis was studied in both *G. nervosum* and *G. Richardsonii* (pl. 6, figs. A, B). The pairing of chromosomes appeared normal and complete. The chiasmata are mostly terminalized at this stage, and rod or ring shaped bivalents were the only types observed. At metaphase the bivalents appeared round in polar view and dumb-bell shaped in side view. Later stages of meiosis were also seen, but showed no irregularities.

Little variation in size of somatic chromosomes was noted within a species. The centromeres were difficult to locate; however, most of them appeared to have a median position.

TABLE 1. CHROMOSOME NUMBERS OF FOUR SPECIES OF GERANIUM.

FIGURE	SPECIES	CHROMOSOME	
		NUMBER*	SOURCE OF MATERIAL
A	<i>G. nervosum</i>	n=26	R. J. Shaw 68, Bear Lake Co., Idaho. Anthers collected in the field.
B	<i>G. Richardsonii</i>	n=26	R. J. Shaw 30, Wasatch Co., Utah. Anthers collected in the field.
C	<i>G. carolinianum</i>	2n=52	R. J. Davis 2290, Idaho Co., Idaho. Grown from seed.
1	<i>G. pusillum</i>	2n=26	R. J. Shaw 36, Cache Co., Utah. Grown from seed.

*In the chromosome counts the 2n number indicates that root tips were examined and the n number indicates that meiosis was studied. Only one plant from each collection was examined with the exception of *G. nervosum*. Since the chromosome number of this species has not previously been reported, additional determinations were made on three other collections all from different counties of the Wasatch region.

To separate *G. nervosum* and *G. Richardsonii*, the two perennial species occurring in the Wasatch region, Jones and Jones used the criteria of petal pilosity and color of the glandular pubescence on the pedicels; at the same time, however,



FIG. 1. *Geranium pusillum*, metaphase in root tip division. Camera lucida drawing, $\times 2000$.

they considered these species to have similar range, habitat, and habit. The writer, after extensive herbarium, field, and controlled greenhouse studies, has found petal pilosity to be quite constant in *G. Richardsonii*, but in *G. nervosum* it is variable, covering from one-fourth to three-fourths of the petal. The color of the glandular hairs on the pedicels was also found to be extremely variable, ranging from colorless to purple in both species depending upon locality. Furthermore, there are definite habitat differences. Thus, while the writer agrees with Jones and Jones as to the specific distinction of *G. nervosum* and *G. Richardsonii*, he feels that the criteria advocated by them are insufficient to separate these two entities.

After comparison of all specimens collected during this study, as well as those obtained from other herbaria and those plants grown under controlled conditions in the greenhouse, the writer found that the following morphological characters furnish adequate bases for specific differentiation between *G. nervosum* and *G. Richardsonii*: color of petals, length of mature styler column (including carpels), and length of seeds. In addition, *G. Richardsonii* is generally found in moist shaded areas especially along fast-moving streams, while *G. nervosum* is a plant of more open xeric sites and is frequently associated with *Artemisia tridentata* Nutt.

DISCUSSION

The chromosome numbers of three species listed by Warburg (1938) do not agree with those here reported. *Geranium carolinianum* was reported by Warburg as $2n=46$ or 48. The root tip smears made by the writer showed 52 to be the $2n$ number (pl. 6, fig. C). Warburg and Gauger (1937) disagree on the count of *G. pusillum*; the former listed $2n=34$ and the latter $2n=26$. Mitotic counts made in this study agree with Gauger's work (fig. 1). Warburg recorded the n number of *G. Richardsonii* as follows: " $n=28?$ ", indicating he was uncertain of his count. In both meiotic and mitotic divisions the writer definitely found that $n=26$ (pl. 6, fig. B).

For his cytological studies Warburg used sections of root tips and flower buds, whereas the writer used smears exclusively. One explanation for the differences of chromosome numbers is the possibility of two different chromosomal races



PLATE 6. CHROMOSOMES OF GERANIUM. FIG. A, *G. nervosum*, diakinesis in pollen mother cell division, $\times 1072$. FIG. B, *G. Richardsonii*, diakinesis in pollen mother cell division, $\times 1577$. FIG. C, *G. carolinianum*, metaphase in root tip division, $\times 1072$.

within one species or a variety being tetraploid and the rest of the species being diploid. Only further research will clarify these discrepancies.

On the basis of cytological data presented, certain suggestions can be made regarding the nature of polyploidy within this genus. From the figures of the meiotic divisions it can be seen that there are no multivalents present and that pairing is normal and complete (pl. 6. fig. A). Furthermore, fertility of all species is high. These facts suggest that at least the two perennial species, *G. nervosum* and *G. Richardsonii* are tetraploids and are probably the typical allopolyploid types described by Stebbins (1947).

TAXONOMY

KEY TO THE SPECIES

Plants annual; petals not more than 7 mm. long.

Fertile stamens 5; sepals awnless.....*G. pusillum*

Fertile stamens 10; sepals awned.....*G. carolinianum*

Plants perennial; petals more than 12 mm. long.

Mature stylar column 2-2.5 cm. long; petals usually white; seed 2-3 mm. long.....*G. Richardsonii*

Mature stylar column 3-3.5 cm. long; petals rose pink; seeds 3-4 mm. long.....*G. nervosum*

1. GERANIUM PUSILLUM Burm. f. Sp. Geran. 27. 1759.

Annual; stems diffusely branched, decumbent or prostrate, puberulent, 1-5 (2)¹ dm. long, base of branches swollen; basal petioles of leaves 10-18 (13) cm. long, puberulent; blade 1-6 (4) cm. broad, orbicular-reniform, 7-9 parted, the division 3-5 toothed or lobed at apex; cauline leaves with short petioles, blades with 3-7 deeply incised segments, otherwise similar to lower leaves; stipules 1-2 mm. long, lanceolate, ciliate on margins; peduncles short, glandular pubescent, 2-flowered; pedicels paired, 2-16 (6) mm. long, bending upward as fruit matures; sepals elliptic to ovate, awnless, 2.5-5 mm. long, minutely glandular pubescent, hispid on the margins; petals purple to violet, about as long as sepals, notched, cuneate; 5 fertile stamens; stylar column 7-9 mm. long, glandular puberulent; carpel bodies 2 mm. long, strigose; seeds 1.5-1.8 mm. long, smooth.

Type locality. England and France.

Range. United States and southern Canada. A weed common in lawns and waste places. Naturalized from Europe.

Representative specimens. UTAH. Cache County: North Logan, *Shaw* 36; Logan, *C. P. Smith* 17669; Pelican Ponds, *J. Thieret* 149.

2. GERANIUM CAROLINIANUM L. Sp. Pl. 682. 1753.

Annual; stems 1-3 rather stout and freely branched, erect, 2-4 (2.8) dm. high, closely short pubescent; petioles of basal leaves 5-15 (9) cm. long, short pubescent; blades 3-7 (4) cm.

¹The number in parentheses indicates the mean measurement.

broad, orbicular-reniform in outline, 5-7 palmately parted and cleft into linear or oblong, obtuse lobes; cauline leaves with varying petioles, 0.5-13 cm. long, blades 3-7 deeply parted, the tips of the segments more acute than the lower leaves; stipules 5-10 cm. long, linear lanceolate; flowers and fruit in compact clusters as a result of the very short peduncles; pedicels 3-15 mm. long, glandular-pubescent, straight at maturity; sepals 5-7 mm. long, ovate, 3-nerved with glandular-pubescence, hyaline, ciliate margin; mucro 1-2 mm. long; petals as long as the sepals, pale pink or whitish, oblanceolate; fertile stamens ten; mature stylar column 12-20 mm. long with glandular hairs; stylodia very short, 1 mm. or less; carpel bodies 3-3.5 mm. long, with villous ascending hairs, black at maturity; seeds 2-2.5 mm. long, oblong, reticulate.

Type locality. Carolina.

Range. Open places or fields throughout North America.

Representative specimens. UTAH. Weber County: Fern Hollow, Ogden, *Winona Cardon 313*.

Geranium carolinianum has been confused with *G. Bicknellii* Britton, the latter having been included in the Wasatch region by at least two authors. Inclusion of *G. Bicknellii* in the flora might possibly have been based upon a collection from Logan Canyon in 1910 (*C. P. Smith 2164*). The stage of the plant's development makes it impossible to determine its true identity.

3. GERANIUM RICHARDSONII Fisch. & Trautv. Ind. Sem. Hort. Petrop. 4:37. 1837.

Perennial, the caudex often branched and covered with brownish, withered, scale-like leaf bases and stipules; stems solitary or few, erect, 30-90 (52) cm. tall, glabrous becoming pubescent near the top; petioles of the basal leaves 5-20 (sometimes 30) cm. long, glabrous or glandular tipped hairs or pilose; blades 3-17 cm. broad, pentagonal in outline, deeply 5-7 parted, the rhombic segments divided several times, strigose on the upper surface and on the prominent veins of the lower surface; cauline leaves with short petioles, blades with 3-5 sharply incised segments with tapering lobes, pubescence similar to that on basal leaves; stipules lanceolate, attenuate, 6-12 mm. long, ciliate on the margins; inflorescence cymose, the peduncles 2-10 cm. long, glandular pilose, the glands being either translucent or purple; pedicels slender, 1-3 (rarely 4) cm. long, paired, becoming bent upward as fruit matures, copiously pubescent with short viscid glandular-tipped trichomes; sepals 6-10 mm. long, lanceolate or narrowly oval, glandular-pubescent especially near the base and veins, margins hyaline; mucro 1-2 mm. long; petals 12-20 mm. long, broadly obovate, entire, milk-white or sometimes pink tinted, usually with purple or pink veins, generally pilose on the inside extending